31 p.

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QUARTERLY PROGRESS REPORT NO. 7

TO

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RADIOISOTOPIC BIOCHEMICAL PROBE FOR EXTRATERRESTRIAL LIFE

CONTRACT NO. NASr-10

DECEMBER 10, 1962

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TABLE OF CONTENTS

22793

22793

I. SUMMARY

Modifications of the medium have been made which decrease the quantities of complex constituents. This has been done by using yeast extract and peptone at concentrations of 1/2 those initially used and completely removing the amino acid hydrolysate from the medium. These changes do not affect the present test cultures adversely and may be better for some of the facultative autotrophic organisms. The new medium will also lend itself better to an examination of the effects of radioactive amino acids planned for the near future.

Efforts to adapt the automatic monitoring unit for the study of chemoautotrophs and anaerobes have not been successful.

Studies of the effects of several antimetabolites have continued. Bard-Parker Germicide can be heated at 135°C for 26 hours and still inhibit the range of test organisms without resulting in excessive sterile control levels.

Sterile control levels have received some attention in conjunction with field testing of the third model of the instrument. Adequate flushing and proper packaging are being studied and will be utilized to maintain acceptable control levels.

A working model of the instrument has been developed which is capable of functioning without attitude control. Mechanical aspects of the field tests with the new instrument have been satisfactory. Full scale field tests are planned for the immediate future.

The solid state radiation detector used previously has been replaced with an anticoincident geiger detection system.

AUTHOR

II. BIOLOGICAL INVESTIGATION

Three areas of specific interest were emphasized in the biological phase of the work over the past three months. These include: (1) efforts to optimize the basic medium, (2) inhibitor studies, and (3) supporting laboratory effort for instrumentation and field testing.

The radioactive substrates used throughout the quarter were glucose-C^{14} (uniformly labeled) and sodium formate-C^{14}. They were combined for use at radioactivity levels of 1.0 uc/ml each (0.002% formate and 0.005% glucose) or 5.0 uc/ml each (0.01% formate and 0.025% glucose). The activity is stated for each determination discussed in the report.

Several changes have been made in the basal medium. For ease of comparison the various media are listed below:

Constituent	Medium - Number		
	M5	M6	M7
K_2HPO_4	1.0 g	1.0 g	1.0 g
KNO_3	0.5 g	0.5 g	0.5 g
$MgSO_4.7H_2O$	0.2 g	0.2 g	0.2 g
NaCl	0.1 g	0.1 g	0.1 g
$FeCl_3$	0.01 g	0.01 g	0.01 g
Soil Extract	250.0 ml	250.0 ml	250.0 ml
Malt Extract	3.0 g	3.0 g	3.0 g
Ascorbic Acid	0.2 g	0.2 g	0.2 g
Beef Extract *	3.0 g	3.0 g	3.0 g
L-Cystine	0.7 g	0.7 g	0.7 g
Na_2SO_3	0.2 g	-	-
Bacto Casamino Acid	4.0 g	4.0 g	-
Yeast Extract	13.0 g	6.5 g	6.5 g
Proteose Peptone #3	20.0 g	10.0 g	10.0 g
Distilled H_2O	up to 1 liter		

* Beef extract was inadvertently omitted from the list of constituents in previous reports.

A. RESPONSE OF TEST MICROORGANISMS

1. Basal Medium

Investigation has continued in an effort to determine the effects various concentrations of yeast extract and peptone originally used in the M5 medium have on CO_2 evaluation. Dilutions of both compounds were made to yield final concentrations of ½ and ¼ the initial concentration contained in M5. During the last three months, soils have been tested using the automated system described in the last report (Table 1). Results from pure cultures were reported in Progress Report No. 6.

Response from the dilutions was better than that obtained from the regular M5 and generally better from the ½ dilution than from the ¼. As with the pure cultures, differences between the diluted media were not usually very pronounced. Initial results with pure cultures suggested that use of ¼ dilutions offered a very slight advantage in general but when all of the results, i.e. both pure cultures and soils are evaluated, use of ½ dilution appears to be advantageous. On this basis, medium M6 was used for a number of determinations.

Consideration has been given to future use of radioactive amino acids in conjunction with the formate and glucose presently used. However, before labeled amino acids can be incorporated into the medium, it is necessary to evaluate the requirement for the amino acid hydrolysate now being used. Several determinations were made using pure cultures representing gram positive bacteria, normally slow growers, normally fast growers, and yeast. The media compared were M6 and M7 listed above. M7 is the same as M6 except for the omission of Bacto Casamino Acids. The results from incubating test organisms in planchets and collecting radioactive CO_2 on pads saturated with $Ba(OH)_2$ are shown in Table 2. It can be seen that omission of the Bacto Casamino Acids was not overly detrimental to any of the organisms tested, and showed a significant advantage for S. cerevisiae.

When tested in chambers using the automatic monitoring system, response from Escherichia coli was identical in both M6 and M7 and response from Staphylococcus epidermidis was better in M7.

Removal of the amino acid hydrolysate from the medium appears to be possible without being detrimental to the response from the organisms tested.

2. Thiobacilli

The chemoautotrophic Thiobacilli responded poorly to the M5 medium as reported in Progress Report No. 6. In an effort to determine whether the unresponsiveness was due to an inability to utilize the complex basic medium or to an inability to utilize the radioactive substrates, Thiobacillus novellus and Thiobacillus thiooxidans were incubated in the medium used to carry the laboratory stock cultures. To the stock medium was added radioactive glucose and formate (5.0 uc/ml of each). Incubation was at room temperature in the automatic monitoring system. The composition of the stock culture medium is: $Na_2S_2O_3$, 5.0 g; $(NH_4)_2SO_4$, 0.3 g; KH_2PO_4, 0.25 g; $CaCl_2$, 0.5 g; $FeSO_4$, 0.01 g; and H_2O to 1 liter.

The response of the Thiobacilli to the radioactive stock medium was no greater than it was to the M5. This suggests that the substrates may not be readily available or that the particular combination of C^{14} substrates and medium are not satisfactory. Continued investigation is planned to increase the responsiveness of the chemoautrophs.

3. Anaerobes

Some effort has been made to adapt the automatic monitoring unit to the study of anaerobic cultures. This was done by utilizing nitrogen to flush the medium and the chambers and then sealing the system with the gas collector and the detector. Response to this method has been variable and indications are that

anaerobiosis is not achieved sufficiently well for the method to be used for all the anaerobic test organisms. Further efforts are being made for the adaptation of the automatic monitoring system to anaerobic determinations.

B. INHIBITOR STUDIES

The inhibitor studies begun during the preceding quarter have been continued. Of the inhibitors initially screened, only Amphyl (potassium ricinoleate, o-phenylphenol, p-tertiary amyl phenol, alcohol, propylene glycol, and glycerol) at a final concentration of 2% and Bard-Parker Germicide (iso-propanol, methanol, formaldehyde, and hexachlorophene) at a final concentration of 10% were considered sufficiently stable and effective. Prior to being tested, both disinfectants were heated at 135°C for 26 hours. All of the determinations were carried out in triplicate using planchets for incubation chambers and collecting the radioactive CO_2 on wet $Ba(OH)_2$ pads. Unseeded controls containing medium alone and medium plus inhibitor were also carried out in triplicate. The planchets were incubated for two hours, and CO_2 was collected for 15 minutes. The cultures were reincubated for an additional two hours, and CO_2 was again collected for 15 minutes. The radioactivity of the dried pads was assayed in a Nuclear-Chicago D-47 end window counter.

In order to eliminate errors in interpreting the apparent inhibition by the Bard-Parker Germicide, the pH values were determined. The pH of the germicide was initially about 6.0 and did not change after being heated at 135°C for 26 hours. The pH of the growth medium was 6.8 initially. The final pH of M5 and Bard-Parker Germicide combined was 6.5, indicating no detrimental alterations in the pH of either the antimetabolite or the growth medium. Heated Bard-Parker was also used in a disc assay against Escherichia coli, Bacillus subtilis, and Mycobacterium phlei seeded on plates. All test organisms were inhibited on the plates.

The Bard-Parker Germicide was generally more stable and more effective

than the Amphyl (Table 3). Unseeded control levels of the inhibited group were fairly stable with Bard-Parker but erratic with Amphyl. The inhibition by the Bard-Parker is not due to pH changes since the pH changed only slightly and inhibition also occurred on plates. Further investigation is required to determine concentration effects in general and the effects of the inhibitors on soil inocula in particular.

C. SUPPORT FOR INSTRUMENTATION

Sterile control levels have remained low and have not been any problem during the laboratory phase of the work. As an example of the stability in the laboratory, one ml quantities of sterile medium incubated at room temperature and assayed with the automatic recording unit remained stable at about 100 CPM for 65 hours. However, at the radioactivity levels currently in use (5.0 uc/ml of each radioactive substrate), multiple autoclaving as used in the sterilization of the instrument for field testing causes an initial increase in the sterile controls above the level desired. Although the level decreases after the medium has been released from the sealed ampule some initial levels have been in excess of 500 CPM. When tested in the instrument without flushing, this results in levels above those desired for maximum test sensitivity.

Several approaches have been investigated in an effort to achieve a minimum level of activity. A study of flushing methods is in progress. It is known that flushing will decrease the sterile control level, although the most efficient flushing system has not yet been determined. A second study is being made to determine the source of the sterile control activity. Progress has been made in this area and it appears that the sodium formate reacts slightly when heated with some constituents in the basal medium. Present indications are that by reducing the amount of formate used or by sterilizing the formate in aqueous solution and

mixing it after sterilization the control levels will remain in an acceptable range. This supportive effort has not yet been completed and will continue.

D. CONFERENCES

Conferences were held with personnel from American Machine and Foundry Company and Jet Propulsion Laboratories on September 26, 1962 at Alexandria, Virginia and with Dr. Norman Horowitz at Resources Research, Inc. on October 17, 1962.

TABLE 1

Response from Desert Soils to
Medium M5 and Dilutions of
Yeast Extract and Peptone

Soil No.	Medium		
	M5	½*	¼*
#1	2	1	3
#1	3	2	1
#68	1	1	2
#68	2	2	1
#70	2	1	2
#70	2	1	2
#74	2	1	-
#74	2	1	-
#76	2	1	-
#76	2	2	1

*Relative concentrations of yeast extract and peptone

Soil numbers represent replicate experiments

Responses rated as: 1 better than 2 better than 3, and are averages of replicate determinations.

The desert soils listed above were provided by the Space Biology Group, Jet Propulsion Laboratory.

TABLE 2

Response of Equal Inocula of Pure Cultures

to Media M6 and M7

Test Organisms	Response - CPM Above Control M6	M7
Control	47	48
Escherichia coli	8,519	5,582
Micrococcus cinnabareus	601	510
Saccharomycies cerevisiae	353	1,031
Staphylococcus epidermidis	45	67

Total incubation and CO_2 collection time = 3½ hours in planchets

M6 and M7 - defined in introduction

Values are averages of triplicates

TABLE 3

EFFECT OF HEATED INHIBITORS ON TEST ORGANISMS

Organism		Radioactivity-CPM					
		Medium Control	Organism*	Bard-Parker		Amphyl	
				Control	Inoc.**	Control	Inoc.**
Azotobacter indicus	2 Hrs.	27	31	49	0	5,020	0
	4 Hrs.	24	471	31	3	717	16,383
Bacillus subtilis spores	2 Hrs.	31	40	30	16	575	0
	4 Hrs.	37	105	24	250	831	0
Arthrobacter simplex	2 Hrs.	36	5,787	65	1,070	-	-
	4 Hrs.	36	2,830	65	755	-	-
Xanthomonas campestris	2 Hrs.	38	370	45	19	-	-
	4 Hrs.	39	679	46	0	-	-
Xanthomonas beticola	2 Hrs.	27	1,108	30	3	115	0
	4 Hrs.	46	11,120	35	2	58	27
Rhodospirillum rubrum	2 Hrs.	36	1,791	65	0	-	-
	4 Hrs.	50	1,620	65	11	-	-
Saccharomyces cerevisiae	2 Hrs.	31	350	30	14	578	0
	4 Hrs.	37	280	24	8	831	-
Staphylococcus epidermidis A -	2 Hrs.	102	27	104	0	-	-
	4 Hrs.	95	88	117	0	-	-
B -	2 Hrs.	38	72	45	59	-	-
	4 Hrs.	39	913	46	38	-	-
Streptomyces bobiliae A -	2 Hrs.	102	107	104	0	-	-
	4 Hrs.	95	62	117	0	-	-
B -	2 Hrs.	38	111	45	188	-	-
	4 Hrs.	39	194	46	225	-	-
Micrococcus cinnaberus	2 Hrs.	36	398	65	0	-	-
	4 Hrs.	50	423	65	23	-	-
Pseudomonas delphinii	2 Hrs.	38	327	45	0	-	-
	4 Hrs.	39	508	46	0	-	-
Pseudomonas fluorescens	2 Hrs.	102	54	105	0	-	-
	4 Hrs.	95	251	117	18	-	-
Azotobacter agilis	2 Hrs.	27	54	49	0	5,020	0
	4 Hrs.	24	574	31	11	717	0

TABLE 3 (contd.)

EFFECT OF HEATED INHIBITORS ON TEST ORGANISMS

Organism		Radioactivity-CPM					
		Medium Control	Organism*	Bard-Parker		Amphyl	
				Control	Inoc.**	Control	Inoc.**
Bacterium bibulum	2 Hrs.	36	43	65	0	-	-
	4 Hrs.	50	182	65	0	-	-
Clostridium sporogenes	2 Hrs.	38	34	45	0	-	-
	4 Hrs.	41	117	48	0	-	-
Escherichia coli	2 Hrs.	31	1,819	30	5	578	13
	4 Hrs.	37	-	24	6	831	0

* Activity above sterile medium control

** Activity above disinfectant control

Organisms were tested in M5 medium with labeled glucose and formate (1.0 uc/ml of each).

Planchets were used to culture organisms and wet $Ba(HO)_2$ pads were used to collect radioactive CO_2

The values are averages of triplicates

Quarterly Progress Report No. 7

NASr-10

December 10, 1962

Respectfully submitted,

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INSTRUMENTATION

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III INSTRUMENTATION

A. INTRODUCTION

In this reporting period, the most important advancement is the development of the instrument to a working model with omnidirectional functional capabilities. Also, the anticoincident geiger detection system brought forth during this period is a major step towards meeting environmental specifications with components within the state-of-the art.

This Seventh Quarterly Report is abbreviated to short topical descriptions due to the current intense effort on the part of all personnel to finish preparations for the feasibility demonstration scheduled for November 27th. In this test, it is planned that Gulliver III will be functionally demonstrated along with auxilliary electronics simulating flight instrumentation. The test calls for completely automatic operation.

B. MECHANICAL ENGINEERING

In the three months of this reporting period, most of the mechanical engineering effort was devoted to assembly and testing of components and to investigating ideas for improvement. Gulliver III has advanced from the layout drawing stage to a field tested demonstration model. Figure 1 is a photograph of this model.

1. Changes

A few modifications were made in the new instrument that are not described in the previous report of 15 August 1962. These were for the most part only minor, the principal change being the substitution of a geiger tube detector in place of a solid state type.

A model of a new 2-hole string port configuration was made and tested for leakage and function. It was concluded that this type was an improvement over the single port and it is being used in the present system.

A new baffle system was tried out in a dummy chamber with good results. This design is now incorporated in the new instrument.

A new reduction box was designed and built for the string winding stepping motor. Subsequent testing revealed that torque was increased from 2.5 ounce inches to 5.75 ounce inches and that there was no corresponding increase in power required. It is felt that this change is inherently more reliable than the old version. As evidence of this, a test in a cold chamber at $32^{o}F$ showed no changes in torque or power consumption from these quantities measured at room temperature.

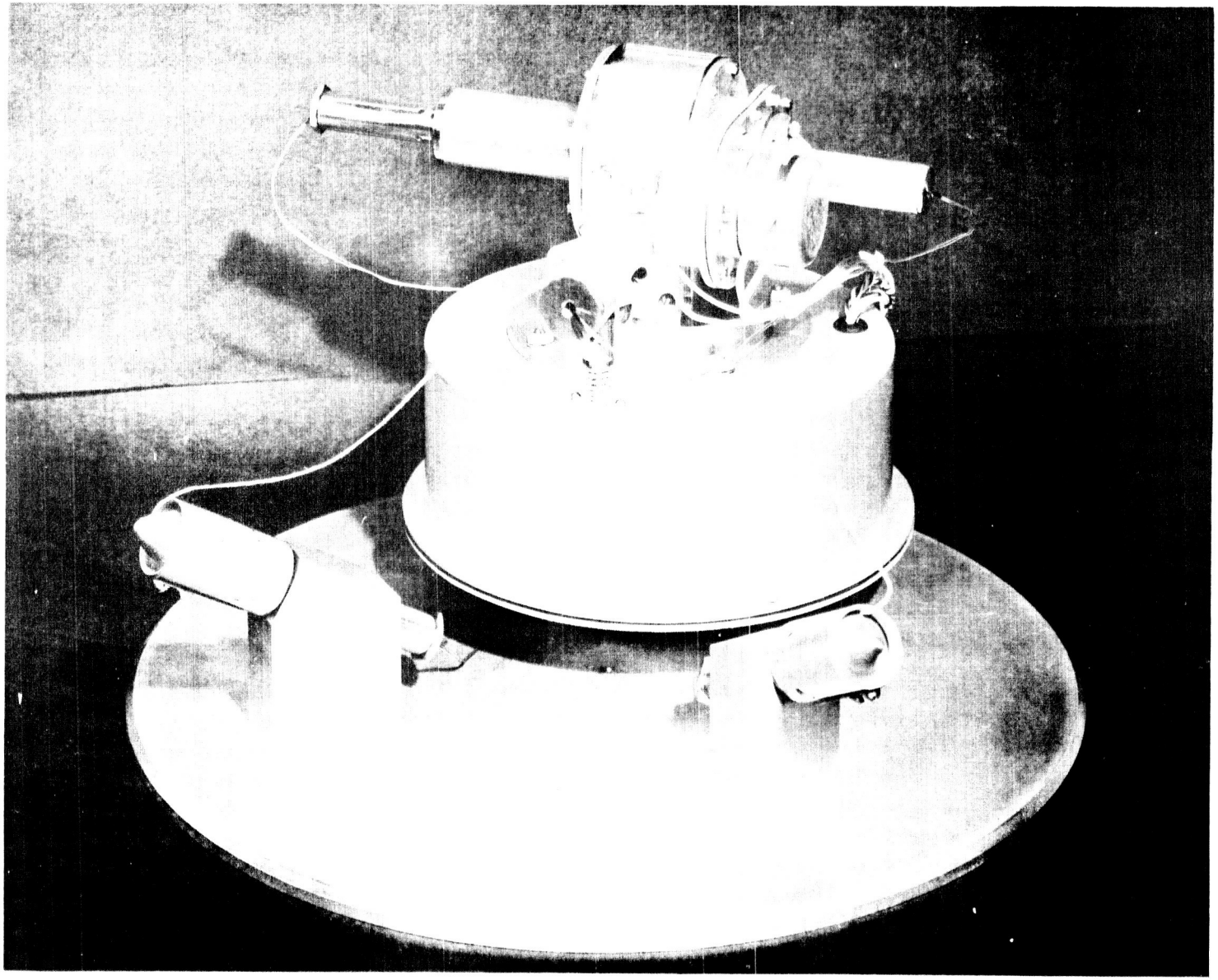

Figure 1. Gulliver, Mark III, the Latest Configuration of the Mars Probe Life Detection Instrument.

Systems for supplying flushing gas have been designed, and in one case, fabricated for use with the demonstration models. The device which was made is not designed to contain gas for the eight month voyage in vacuum, but does provide a feasibility feature to the demonstration instrumentation. A "space resistant" design has also been considered, but due to the as yet uncertain requirements for flushing, this device has not been made.

2. Fabrication of Instruments

Shop drawings were made and turned over to the machine shop for fabrication of two complete instruments. A third unit is under construction. The quality of work by the shop is considered excellent. During assembly, further minor modifications were incorporated where improvements became apparent.

After assembly, functional tests were performed to check for proper working of all mechanisms. It was gratifying to find that there were no discrepancies in the design or manufacture.

3. Powder Contamination

Concern has been expressed that powder or gas from the explosive squibs used to break the broth ampule and to seal the string port might leak past the "O" ring seals into the incubation chamber; that this foreign matter might then poison the culture in some way. Accordingly, powder contamination tests were run, using the diphenylamine test for the presence of nitro groups. Moistened pads from the incubation chamber indicated that no gas or powder had passed the seals.

4. Sample Collection

Projectile and sample collection tests have continued. A new type of high power squib was tried in outdoor firings with string loaded projectiles. The string broke several times and the unwinding string jammed in the projectile in some cases. The decision was made to revert to the low power squibs since they are satisfactory with a new winding scheme which has a reliability factor of 100% for about 35 shots.

This new type of winding changes from the overlapping roll-on style to a fore and aft series of layers carefully packed at right angles. In order that the reliability of this method can be ascertained, several loading jigs were made so that numerous projectiles can be wound with relative ease, and a test firing stand has been devised for multiple loadings. Plans are to achieve from 10 to 15 firings per day and to get statistical results on reliability of the projectiles.

5. Field Tests

During the two full scale field tests, the mechanical system of the new instrument worked very well.

6. Thermal Tests

Temperature measurements to determine the heat distribution throughout the instrument have been made. The heating system of Gulliver III consists of a thermostat on one side of the incubation chamber and an electrical resistance heating pad on the opposite side. Thermocouples were installed at important locations in the instrument to provide data on the temperature profile when the temperature in the test chamber was about 8°F. The results were very gratifying

in that the temperature in the chamber was controlled within a range of 76°F to 81°F with a 78°F thermostat.

C. RESEARCH

1. Internal Gas Flow Counter

An Amperex side-window flow counter was obtained for investigation of the possibilities in using a counter of this general type. Argon-methane was used as the counting gas and a voltage of about 1800 v was required for operation in the beta region. A transistor pre-amplifier with a voltage gain of 800 was designed. This device is necessary because the counter output pulses are of insufficient amplitude to drive conventional scalers.

The advantages of mylar for the side window could be utilized if the inner surface were conductive. This was easily accomplished by using metallized mylar. This feature was very convenient for the purposes of the tests. It was only necessary to coat a gas collection compound on one side of a section of mylar which was aluminized on both sides; then, merely by inverting the mylar, the sample could be located either inside or outside the counter as desired. The data from this experimentation are included below in paragraph C 3.

2. Geiger Tube Protection

An experiment was conducted to determine whether or not a standard geiger tube like the one used in Gulliver III could be used at Mars atmospheric pressure (1/10 earth atmosphere). A protective screen was fashioned so that it had the same contour as the geiger window. This was then attached in such a manner that the screen supported the window as the window bowed out under low-

pressure. The tube seemed to work normally until a vacuum of 27.5 inches was reached, at which point it became erratic for a while. It later settled down and appeared normal at 27.5 inches of vacuum.

3. Comparison of Detectors

It was felt that a re-evaluation of detectors was necessary due to the decreased sensitivity evident in field tests relative to laboratory results.

Quantitative data were necessary for comparison of detectors for C^{14}. Actually the spectrum of interest was not that of C^{14} but a modified one due to the self-absorption of the gas collector. In order to obtain this condition, sources used in this test were $Ba(OH)_2$ samples, which had been exposed to $C^{14}O_2$.

Detectors used were:

1. 1.4 mg/cm^2 end window G-M tube
2. 3 cm^2 surface barrier solid state detector, resolution 30 kev, fwhm
3. Amperex side window gas flow proportional counter

Sources much smaller than the detectors were used in this test in order to minimize geometrical effects.

The results of the comparison tests are as follows:

	G-M cpm	Solid State cpm	Gas Flow cpm	
			Inside	Outside
Sample 1	7,700	5,200	16,000	8,100
Sample 2	20,000	16,000	45,000	29,000
Sample 3	30,000	22,000	66,000	40,000

The above results, coupled with proof that thin end-window tubes can be made to withstand the required environmental conditions for a space vehicle, convinced us that the best detector for an instrument such as Gulliver, considering current state-of-the-art and engineering details, was a small G-M tube in an anti-coincidence configuration.

Amperex tubes 18515 and 18550 are currently being used with an anti-coincidence circuit for field tests.

4. Flushing Experiments

Experiments to determine the flushing gas requirements have continued. A series of checks with $C^{14}O_2$ in solution injected into chenille and flushed with air showed unaccountable variance in the effect of flushing from one experiment to the next, supposedly duplicate, experiment. Learning only that reproducibility was of paramount importance before conclusions could be drawn validly, a more elaborate experimental setup was tried. This was accomplished by saturating sterile non-tagged broth with strongly tagged CO_2 and loading into ampules in such a manner that each should contain the same amount of broth, CO_2, and radioactivity. These ampules were then broken in the dummy incubation chamber with a geiger tube detector in place over the baffle. The only outlet for CO_2 was the single string port so that the geiger tube detected free tagged gas and allowed an assessment of the relative amount of gas in the chamber as a function of time.

Results were surprising. The first run showed a sharp peak and rapid decline in counts per minute back to background in about 20 minutes without flushing. The second run, though supposedly like the first, showed a smoother peak and a gradual decline so that after 3 hours the count rate was still above

background. In the third run, the discrepancy was discovered as being caused by the air flow of the fume hood--the higher the velocity of air past the chamber, the faster the count rate went down. An isolation box was set up in the fume hood so that the dummy chamber was in dead air and a fourth run was made. Here the activity hardly peaked at all, but rather started a gradual decline. After 15 minutes it was flushed with 100 ml of CO_2 within one minute; the effect was noticable, but hardly pronounced. Half an hour later, the flushing was repeated with the same result. These tests were made at earth atmospheric conditions. The next step is to run the experiment at pressures equivalent to those of Mars to see if there is a radical difference in response to flushing due to the lower pressure.

5. Gas Collection Experiments

A mixture of $BaCO_3$, $BaC^{14}O_3$, and powdered citric acid were placed in a weighing bottle which was set in a gas tight metal box. Water was introduced into the mixture via a burette sealed in the top of the box. Upon being wetted, the carbonate and acid reacted to produce CO_2 and $C^{14}O_2$. Thus, by placing gas collector samples inside the box, equal exposure to $C^{14}O_2$ was attained for each sample. Early investigation showed $Ba(OH)_2$ much superior as a CO_2 absorber to activated charcoal and to molecular sieves.

Attempts were made using silk screen techniques to coat adhesives in a uniform manner on flat surfaces, in order to develop a method of coating geiger tube windows with $Ba(OH)_2$. Adhesives used were Bondmaster M683 (160 hardener), RTV-102, Elmer's Epoxy-Metal Compound (Borden Chemical Co.) and Bostik adhesives Nos. 4045 and 4585. The Bostiks were poor adhesives for this purpose.

Coating was accomplished by mixing adhesives with $Ba(OH)_2$ which had been sifted through a 160 mesh screen. The adhesives were then mixed as necessary with appropriate solvents in order to obtain viscosities suitable for the silk screen process.

Elmer's Epoxy-Metal Compound was judged the best of the adhesives tested. Additional investigation is required, especially of those adhesives listed in JPL Spec. No. 30257.

Three general methods of depositing $Ba(OH)_2$ were used: mixture with adhesive before coating as described above, spraying the $Ba(OH)_2$ powder onto Krylon which had been sprayed immediately before, and deposition of a saturated methanol -- $Ba(OH)_2$ solution from which the methanol quickly evaporated. With all techniques it is important that the time between preparation and use be kept to a minimum or that the procedure be carried out in a CO_2-free atmosphere, in order to minimize effects of atmospheric CO_2 absorption. In all tests, pads wet with a saturated $Ba(OH)_2$ water solution are used as references for collector sensitivity.

Tests are still in progress on the above methods. The alcohol solution method holds particular promise.

D. ELECTRONIC ENGINEERING

1. Geiger Detectors and Associated Circuitry

As mentioned previously, geiger detectors are the current preferred choice to provide a C^{14} detection system for Gulliver III which 1) has reasonable detection efficiency, 2) is within the "state-of-the-art" for flight equipment, 3) does not

require mechanical modification of the mechanical system, and 4) does not require critical, complex circuitry. There were a number of anticoincidence geiger systems considered -- including those available from Amperex Electronic Corporation, Lionel Corporation, Eon Corporation, and others. None of the immediately available systems were completely satisfactory when weighed against our desires as to size, weight, power, etc. and against the required environmental specification for flight instrumentation. However, a very desirable geiger tube pair could evolve from a very limited development program carried out by one of the geiger tube manufacturers. To simulate the detector system that would evolve, an anticoincidence configuration with outside dimensions of about 2" diameter by 2" high was assembled using an Amperex 18515 beta detecting geiger. This was "protected" by eleven Amperex 18550 gamma detecting geigers. These tubes can operate well at the same voltage. (550 volts is being used.) The 18515 is a 1" O.D. by 0.67" long thin end-window geiger. Limited anticoincidence protection is provided by the eleven 18550's (5/16" O.D. by 2" long) which are mounted around the periphery of the 18515 with their axes parallel to that of the 18515.

For the anticoincidence operation, the eleven "guard" tubes are wired in parallel and a pulse from any of these 18550 tubes coincident with a pulse from the 18515 beta tube blocks the pulse from the beta tube. Only those pulses from the beta tube appearing in anticoincidence (without a simultaneous pulse from the guard tubes) are permitted to be counted. The dead time of the guard tubes is about 250 microseconds and the beta tube dead time is about 75 microseconds. The dead time of the anticoincidence circuit is limited by the dead time of the detectors and not the circuit since the output pulse from this circuit to the

counter or scaler is a standard 6 microsecond wide rectangular pulse.

A schematic of the circuits being used for the detectors is shown in Figure 2.

The high voltage power supply for the geiger tubes is a Components Corporation Model 65-C, which is a potted unit. This supply operates from a 6 volt positive supply. The high voltage output is adjustable from 450 to 750 volts by changing the value of an external resistor. It provides 50 microamp at 550 volts. The regulation of the output voltage is $\pm$ 1% against input voltages from 5 to 7 volts and for the temperature range from $0^{\circ}C$ to $50^{\circ}C$.

2. Stepping Motor Circuit

The stepping motor driving circuit, also shown in Figure 2, is essentially the same as the one described in the last quarterly progress report. It has been reduced to a printed circuit board for location inside the electronics package, visible in Figure 1 as the drum beneath the main instrument body. The increase in the torque to 5.75 ounce inches was partially the result of optimizing the actuating pulse duration and repetition rate.

3. Scale of 64 and Transmission Equipment

Some consideration was given to use of a radio transmitter and receiver for relaying data from the detector circuitry to a data display system for field test and demonstration purposes. In order to reduce the band width required for direct transmission of the data during high counting rate periods, it was decided that the capability should be provided for using a "scale down" of 64. This can be attained with six flip-flop stages. Commercially available flip-flop modules

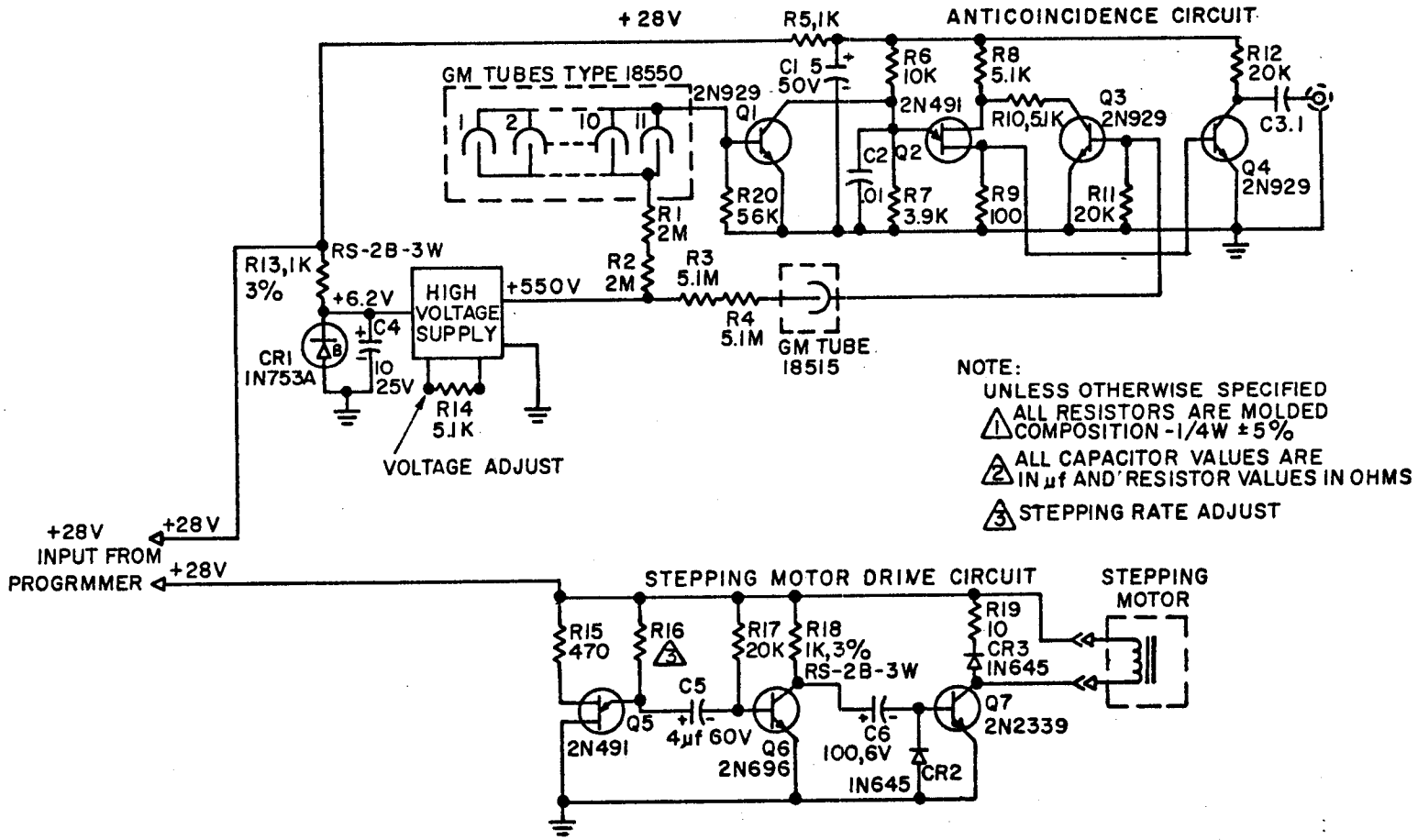

Figure 2. Anticoincidence and Stepping Motor Drive Circuits

and those being utilized by government agencies have been and are being investigated. The components for several such "scalers" are on hand and are being tested. It is planned that this scaler will also be located in the existing electronics package for field test and demonstration purposes since the modules are small and the space occupied in the present electronics package by the detector power supply and circuitry and the stepping motor circuitry is only about one-third of the available volume.

4. Programmer and Power Supply for Field Operations

For field testing and demonstration of Gulliver III, the basic power is supplied by a 12 volt storage battery. An inverter of 85 watt capacity which was described in the 5th Quarterly Report (15 May 1962) converts this 12 volts DC to 110 AC. The 110 volts AC is available for operating any transistorized laboratory type equipment needed in the field. To operate the basic Gulliver system with 28 volts DC (power typical for space craft), the 110 volts AC is stepped down to 25 volts AC, rectified, and filtered.

The programmer presently being used for the field operations is a nine channel industrial timer with an adjustable cam for each channel, and it operates on 110 volts AC power. It, too, was described in the 5th Quarterly Report of May 1962. The timer channels carry 28 volts DC to provide signals to actuate the electromechanical devices of Gulliver III. Since the new instrument operations are somewhat different than those of Gulliver II, the wiring of the timer was reworked and the cams were reset.

To check the effects of the discharge of the 12 volt supply battery on the 110 volt AC output of the inverter and the resultant effects on the 28 volts DC for Gulliver, a 40 watt load (greater than the system requirements) was put on the 110 volt output and voltages and frequency were measured as a function of time. At ambient room temperatures no detrimental results were observed after 16 hours of operation.